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(54) **A planar antenna**

(57) A planar antenna (100) comprising: a signal plane (102), the signal plane (102) having a feed point (118) and a ground point (124); a ground plane (104); a dielectric (106) between the signal plane (102) and the ground plane (104); a connection structure (114) for connecting the feed point (118) and the ground point (124), the connection structure (114) being located in the dielectric (106).

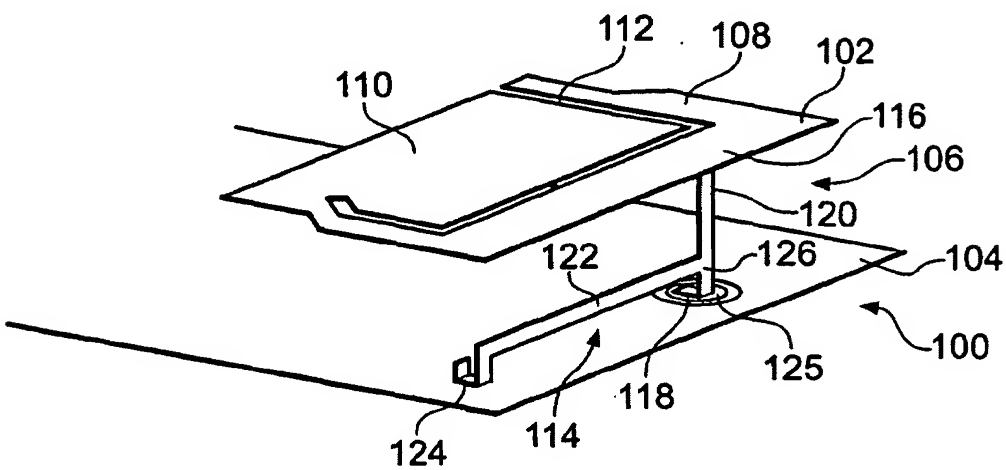

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a planar antenna. In particular, but not exclusively, it relates to an antenna having broad or multiband performance for mobile (wireless) communication devices, such as PIFAs (Planar Invented-F Antennas) or the like.

BACKGROUND OF THE INVENTION

[0002] Most conventional mobile wireless communication devices employ either external antennas such as helical wound types or retractable antenna, or internal antennas which have planar structures with a ground plane, a signal plane and a dielectric substrate, eg. air, therebetween.

[0003] Planar structures are commonly known as Planar Inverted-F Antennas or PIFAs. These well known antennas comprise resonating structure or structures on the signal plane with an electrical grounding point and feed point. The grounding point is made by an electrical connection to the ground plane.

[0004] Examples of known PIFAs are disclosed by EP1096602, EP1094545 and EP1083624, for example.

[0005] The grounding point may be a distance from the feed point and joined by an electrical structure or "matching bridge". By adjusting the length of the "matching bridge" on the signal plane, the input impedance of the antenna can be changed. The "matching bridge" occupies an area of the signal plane and hence contributes to the overall physical volume of the antenna.

[0006] The physical volume, namely the height, width and length, of a PIFA antenna have a major influence on electrical performance aspects such as efficiency and bandwidth. A larger physical volume can generally offer improved electrical performance but normally there is requirement to minimise the physical volume to meet other product requirements.

[0007] There is also an increasing need for multi or broadband antennas. These often require a greater number of resonating structures on the signal plane and consequently increase the physical volume compared to that occupied by a single band antenna.

SUMMARY OF THE INVENTION

[0008] The object of the present invention is to minimise the physical volume of a planar antenna such as a multiband PIFA antenna while maintaining its electrical performance.

[0009] This is achieved according to an aspect of the present invention by introducing a connection structure within the dielectric between the signal plane and ground plane. The connection structure is connected to the RF feed point. This eliminates the matching bridge, reducing the area of the signal plane and thus reducing the volume of the antenna. The connection structure of the present invention therefore achieves the reduction in physical volume while maintaining (or improving) the electrical performance of the antenna.

[0010] The antenna also enables easy adjustment of frequency tuning with minimum effect on bandwidth.

[0011] Such a connection structure of the present invention enables it to be located on a printed circuit board. The connection structure can also form the RF feed point connection path.

[0012] The bandwidth in each frequency band can easily be adjusted by altering the point at which the ground connection path joins the feed connection path.

[0013] The impedance in each frequency band can be easily be adjusted by simply moving the position of the feed point while avoiding the need for other changes to the signal plane.

[0014] The connection structure of the present invention also allows fine adjustment of the bandwidth in each frequency band by merely adjusting the width and length of the connection structure.

[0015] In an embodiment of the present invention, the multiband requirements for two broadband resonances can be realised by a simple resonating structure consisting of two branch arms on the signal plane separated by a single slot.

BRIEF DESCRIPTION OF DRAWINGS

[0016] For a more complete understanding of the present invention, reference is made to the following detailed description taken in conjunction with the accompanying drawings, wherein:

Figure 1 illustrates a planar antenna according to a preferred embodiment of the present invention;

Figure 2 illustrates a planar antenna according to another preferred embodiment of the present invention;

Figures 3a, 3b and 3c illustrate the bandwidth characteristics of a standard PIFA, an antenna according to the first embodiment as shown in Fig. 1 and an antenna according to the second embodiment as shown in Fig. 2, respectively;

Figures 4a to 4f are Smith charts comparing the input impedance of the antenna according to the first embodiment of Fig. 1;

Figures 5a to 5f are the corresponding VSWR plots for the Smith charts of Figs. 4a to 4f; and

Figure 6 is a schematic diagram of the connection structure utilised to generate the results shown in Figs. 4a to 4f and Figs. 5a to 5f.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0017] A preferred embodiment of the present invention will now be described with reference to Figure 1. The planar antenna 100 comprises a signal plane 102, a ground plane 104 and a dielectric substrate 106 therebetween. In the preferred embodiment the dielectric substrate comprises air and the signal plane 102 and ground plane 104 are planar conductive sheets which are substantially parallel and spaced apart at a predetermined distance in order to obtain the desired performance of the antenna. The signal plane 102 comprises two branches 108, 110 separated by a single slot 112 to give the multiband characteristics, in this case dual band, required for the antenna. Although only two branches are illustrated here, it can be appreciated that any number of branches can be realised depending on the multiband requirements.

[0018] The antenna further comprises a connection structure 114 which consists of a feed point 116, a RF feed connection 118, a feed connection path 120, a ground connection path 122 and a ground connection point 124.

[0019] The feed point 116 is the point at which the connection structure 114 connects to a branch 108 of the signal plane 102. The RF feed connection 118 is the point at which the RF input is provided to the antenna and is located on a portion 125 of the ground plane 104. The feed connection path 120 is the path which extends between the feed point 116 and the RF feed connection 118. In the preferred embodiment of the present invention the connection of the feed point 116 to the branch 108 of the signal plane 102 is made on the underside surface of the signal plane 102 within the dielectric 106 and the portion 125 of the ground plane 104 is provided on the upper surface of the ground plane 104 also within the dielectric 106.

[0020] One end of the ground connection path 122 is connected at a connection point 126 on the feed connection path 120. The other end of the ground connection path 122 is connected to the ground connection point 124. In the preferred embodiment, the ground connection path 122 comprises an elongated conductive strip which is integral with the feed connection path 120. The ground connection path 122 of the preferred embodiment extends generally parallel to the plane of the ground plane 104. The connection point 126 and the ground connection point 124 being at a predetermined distance apart. The ground connection point 124 is provided by extending the ground connection path 122 downward toward the ground plane 104, bending the ground connection path 122 such that a portion of the ground connection path 122 contacts the ground plane 104 providing a secure attachment area to the ground plane 104.

[0021] The provision of the connection structure 114 within the dielectric of the antenna reduces the volume occupied by the antenna by approximately 12%.

[0022] In the alternative embodiment shown in Figure 2, the volume occupied by the antenna 200 is further reduced by reducing the surface area of the signal plane 202, by providing a portion 228 of the signal plane 202 within the dielectric 206 of the antenna 200. The planar antenna 200 according to the second embodiment of the present invention comprises a signal plane 202, a ground plane 204 and a dielectric substrate 206 therebetween. As in the preferred embodiment described above, the dielectric substrate 206 comprises air and the signal plane 202 and ground plane 204 are planar conductive sheets which are substantially parallel and spaced apart at a predetermined distance to obtain the desired performance of the antenna. The signal plane 202 comprises two branches 208, 210 separated by a single slot 212 to give the multiband characteristics, in this case dual band, required for the antenna 200.

[0023] The antenna 200 further comprises a connection structure 214 which consists of a feed point 216, a RF feed connection 218, a feed connection path 220, a ground connection path 222 and a ground connection point 224.

[0024] The feed point 216 is the point at which the connection structure 214 connects the portion 228 of the first branch 208 of the signal plane 202. In the preferred embodiment, the feed point 216 is on the edge of the portion 228 of the first branch 208 which is located within the dielectric 206. The RF feed connection 218 is the point at which the RF input is provided to the antenna 200 and is located on a portion 225 of the ground plane 204. The feed connection path 220 is the path which extends between the feed point 216 and the RF feed connection 218. The portion 225 of the ground plane 204 is provided on the upper surface of the ground plane 204 within the dielectric 206.

[0025] One end of the ground connection path 222 is connected at a connection point 226 on the feed connection

path 220. In the preferred embodiment, the connection point 226 is in the proximity of the RF feed connection 218. The other end of the ground connection path 222 is connected to the ground connection point 224. As in the preferred embodiment above, the ground connection path 222 comprises an elongated conductive strip which is integral with the feed connection path 220. The ground connection path 222 of the preferred embodiment extends generally parallel to the plane of the ground plane 204. The connection point 226 and the ground connection point 224 being at a predetermined distance apart. The ground connection point 224 is provided by extending the ground connection path 222 downward toward the ground plane 204, bending the ground connection path 222 such that a portion of the ground connection path 222 contacts the ground plane 204 providing a secure attachment area to the ground plane 204.

[0026] Providing a portion 228 of the signal plane 202 within the dielectric further reduces the volume occupied by the antenna whilst maintaining its characteristics. The volume of the antenna 200 according to the second embodiment of the present invention reduces the volume occupied by a standard antenna by approximately 25%.

[0027] The portion 228 of the signal plane 202 is located within the dielectric 206 by bending the signal plane 202 such that the portion 228 of the signal plane 202 extends downwards in a direction approximately perpendicular to the plane of the signal plane 202 toward the ground plane 204.

[0028] In yet another alternative embodiment, not shown here, the ground connection path 122 can be realised in the form of a printed copper track on the top surface of the ground plane. This reduces the number of connection points between the signal plane and ground plane without loss in performance.

[0029] The S11 bandwidth characteristics of a standard planar antenna similar in construction to that described above and illustrated in Fig. 1 except that the electrical structure or "matching bridge" is of a conventional construction is shown in Fig. 3a. The bandwidth characteristics of a planar antenna corresponding to that of the first embodiment shown in Fig. 1 is shown in Fig. 3b. The bandwidth characteristics of a planar antenna corresponding to that of the second embodiment shown in Fig. 1 is shown in Fig. 3c. The antennas used to achieve the results in Figs. 3a to 3c were manufactured utilising a PCB (ground plane) having approximate dimensions of 116 mm by 40 mm. The signal plane of the standard antenna, which produced the results shown in Fig. 3a, comprised a signal plane having approximate dimensions of 32 mm by 17mm at a height of 9 mm above the ground plane, the dielectric being air. The signal plane of the antenna according to the first embodiment, which produced the results shown in Fig. 3b, comprised a signal plane having approximate dimensions of 32 mm by 15mm at a height of 9 mm above the ground plane, the dielectric being air. The signal plane of the antenna according to the second embodiment, which produced the results shown in Fig. 3c, comprised a signal plane having approximate dimensions of 32 mm by 13mm at a height of 9 mm above the ground plane, the dielectric being air.

[0030] Table I below lists the frequencies at the -5dB points 301, 302, 303 and 304 as show in Figs. 3a to 3c

TABLE I

Point taken from graphs shown in Figs. 3a to 3c	Frequency of standard antenna (Fig. 3a)	Frequency of antenna according to the first embodiment (Fig. 3b)	Frequency of antenna according to the second embodiment (Fig 3c)
301	840 MHz	840 MHz	840 MHz
302	950 MHz	960 MHz	970 MHz
303	1.7 GHZ	1.7 GHZ	1.7 GHz
304	2.0 GHz	2.1 GHz	2.1 GHz

[0031] As illustrated in Table I above, the performance of the antenna according to the preferred embodiments above is comparable with a better bandwidth performance to that of a standard antenna whilst significantly reducing the volume occupied by the antenna of the preferred embodiments to that occupied by a planar antenna of standard construction.

[0032] Figures 4a to 4h and figures 5a to 5h are Smith charts and the corresponding VSWR plots of the S 11 bandwidth for a variety of antennas constructed according to the antenna of the first embodiment shown in Fig. 1. The signal plane of the antenna used to produce these results is a quad band antenna. A schematic representation of the connection structure 114 of the antenna used to generate these Smith charts and VSWR plots is shown in Fig. 6. The connection structure has a length 1 which corresponds to the distance between the RF feed connection 118 and the ground point 124, a height h which corresponds to the height h of the ground connection path 122 above the ground plane and width w corresponds to the width of the ground connection path 122.

[0033] Figures 4a and 5a are the Smith charts and corresponding VSWR plots for input impedance of the antenna over the frequency range 850 to 1150 MHz. A comparison was made of variation in the height, h, of the ground connection path 122 above the ground plane. The plot 401 is that produced for a height, h of 1.0 mm. The plot 402 is that

produced for a height, h of 2.0 mm. The plot 403 is that produced for a height, h of 3.0 mm.

[0034] Figures 4b and 5b are the Smith chart and corresponding VSWR plots for S11 response of the antenna over the frequency range 1900 to 2400 MHz. Again, a comparison was made of variation in the height, h, of the ground connection path 122 above the ground plane. The plot 404 is that produced for a height, h of 1.0 mm. The plot 405 is that produced for a height, h of 2.0 mm The plot 406 is that produced for a height, h of 3.0 mm.

[0035] Figures 4c and 5c are the Smith charts and corresponding VSWR plots for input impedance of the antenna over the frequency range 850 to 1150 MHz. A comparison was made of variation in the width, w, of the ground connection path 122. The plot 407 is that produced for a width, w of 2.2 mm. The plot 408 is that produced for a width, w of 1.6 mm. The plot 409 is that produced for a width, w of 1.0 mm.

[0036] Figures 4d and 5d are the Smith chart and corresponding VSWR plots for input impedance of the antenna over the frequency range 1900 to 2400 MHz. Again, a comparison was made of variation in the width, w, of the ground connection path 122. The plot 410 is that produced for a width, w of 2.2 mm. The plot 411 is that produced for a width, w of 1.6 mm. The plot 412 is that produced for a width, w of 1.0 mm.

[0037] Figures 4e and 5e are the Smith charts and corresponding VSWR plots for input impedance of the antenna over the frequency range 850 to 1150 MHz. A comparison was made of variation in the length, 1, of the ground connection path 122. The plot 412 is that produced for a length, 1 of 18.5 mm. The plot 413 is that produced for a length, 1 of 19.5 mm. The plot 414 is that produced for a length, 1 of 20.5 mm. The plot 415 is that produced for a length, 1 of 21.5 mm.

[0038] Figures 4f and 5f are the Smith chart and corresponding VSWR plots for input impedance of the antenna over the frequency range 1900 to 2400 MHz. Again, a comparison was made of variation in the length, 1, of the ground connection path 122. The plot 416 is that produced for a length, 1 of 18.5 mm. The plot 417 is that produced for a length, 1 of 19.5 mm. The plot 418 is that produced for a length, 1 of 20.5 mm. The plot 419 is that produced for a length, 1 of 21.5 mm.

[0039] Figures 4a to 4f and Figures 5a to 5f illustrate the variations that can be made to the characteristics of the antenna by mere adjustments of the height, width and length of the connection structure and also by adjustment of the size of the ground plane.

[0040] Although preferred embodiments of the apparatus of the present invention have been illustrated in the accompanying drawings and described in the forgoing detailed description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous variations, modifications without departing from the scope of the invention as set out in the following claims.

Claims

1. A planar antenna comprising:

a signal plane, the signal plane having a feed point and a ground point;
a ground plane;
a dielectric between the signal plane and the ground plane;
a connection structure for connecting the feed point and the ground connection point, the connection structure being located in the dielectric.

2. A planar antenna according to claim 1, wherein the connection structure comprises a ground connection path and a feed connection path.

3. A planar antenna according to claim 2, wherein the ground connection path and the feed connection path are interconnected at a connection point.

4. A planar antenna according to claim 3, wherein the position of the connection point is adjusted to adjust the bandwidth of the antenna.

5. A planar antenna according to any one of claims 1 to 4 wherein the antenna is a multiband antenna.

6. A planar antenna according to claim 5, wherein the signal plane comprises a plurality of resonate branches.

7. A planar antenna according to claim 6, wherein the resonate branches are separated by at least one slot within the signal plane.

8. A planar antenna according to any one of the preceding claims, wherein the antenna further comprises means for increasing the electrical length between the feed point and the ground connection point.

9. A planar antenna according to any one of the preceding claims, wherein a portion of the signal plane is located in the dielectric.

10. A planar antenna according to claim 9, wherein the portion of the signal plane located within the dielectric is formed by folding the portion of signal plane into the dielectric.

11. A planar antenna according to any one of the preceding claims, wherein the dielectric is air.

12. A mobile communication device comprising a planar antenna according to any one of the preceding claims.

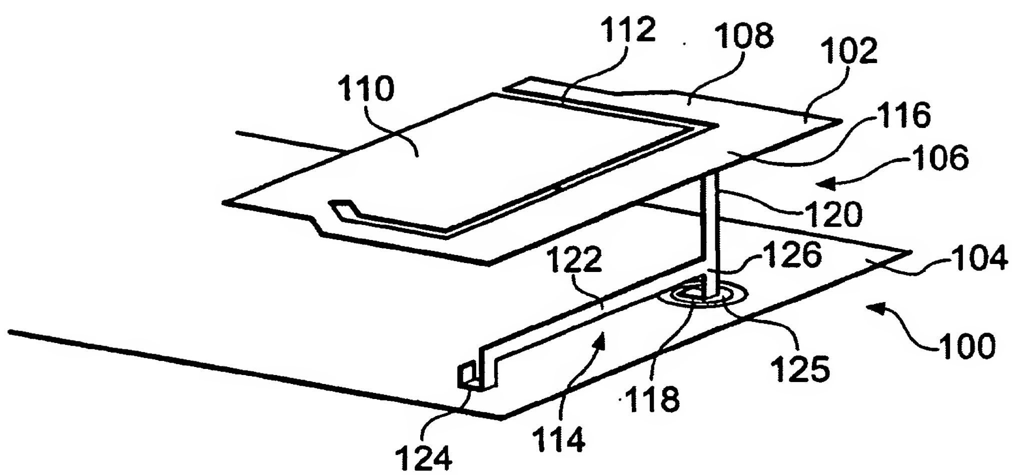


Fig. 1

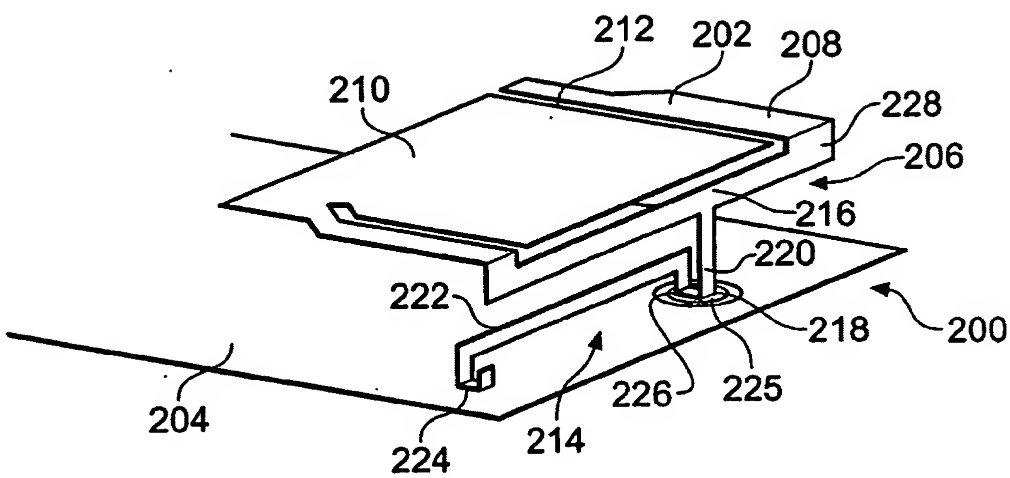


Fig. 2

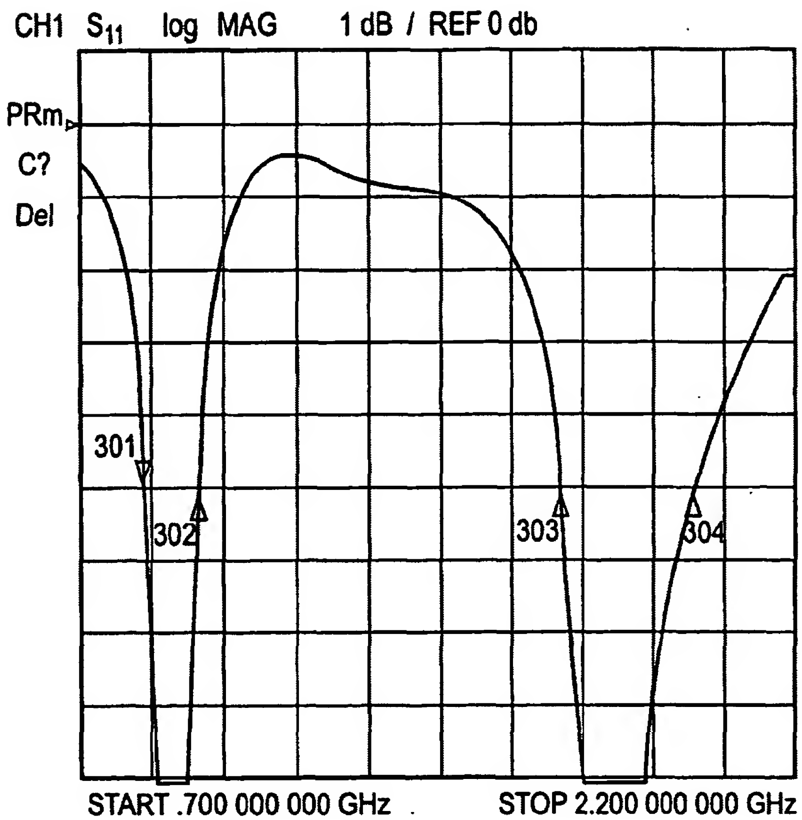

CH1 S11 log MAG 1 dB / REF 0 db
PRm
C?
Del
301
302
303
304
START .700 000 000 GHz
STOP 2.200 000 000 GHz

Fig. 3a

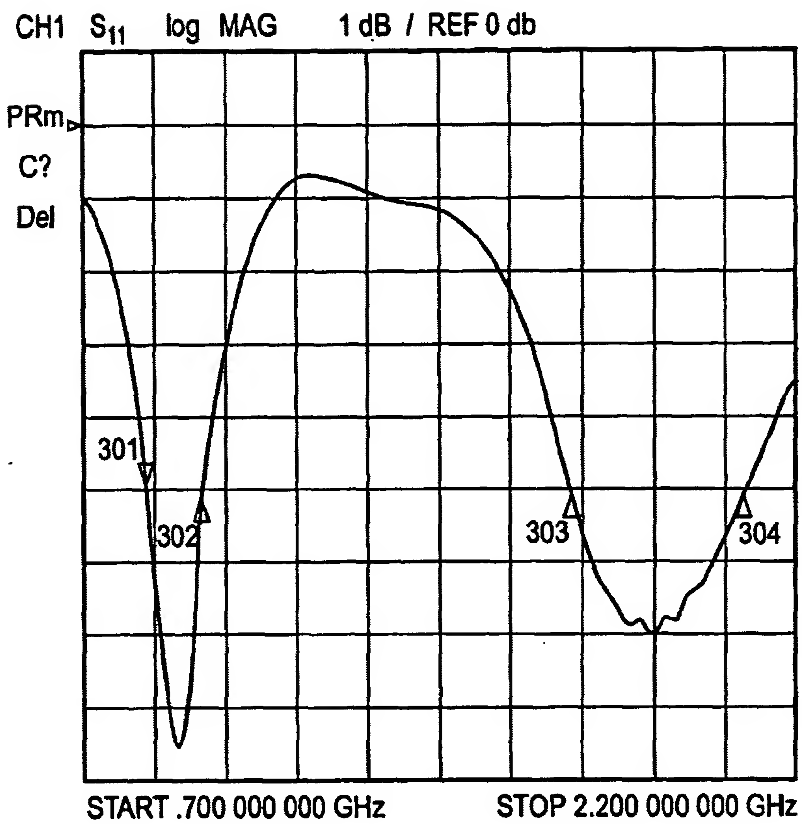

CH1 S11 log MAG 1 dB / REF 0 db
PRm
C?
Del
301
302
303
304
START .700 000 000 GHz
STOP 2.200 000 000 GHz

Fig. 3b

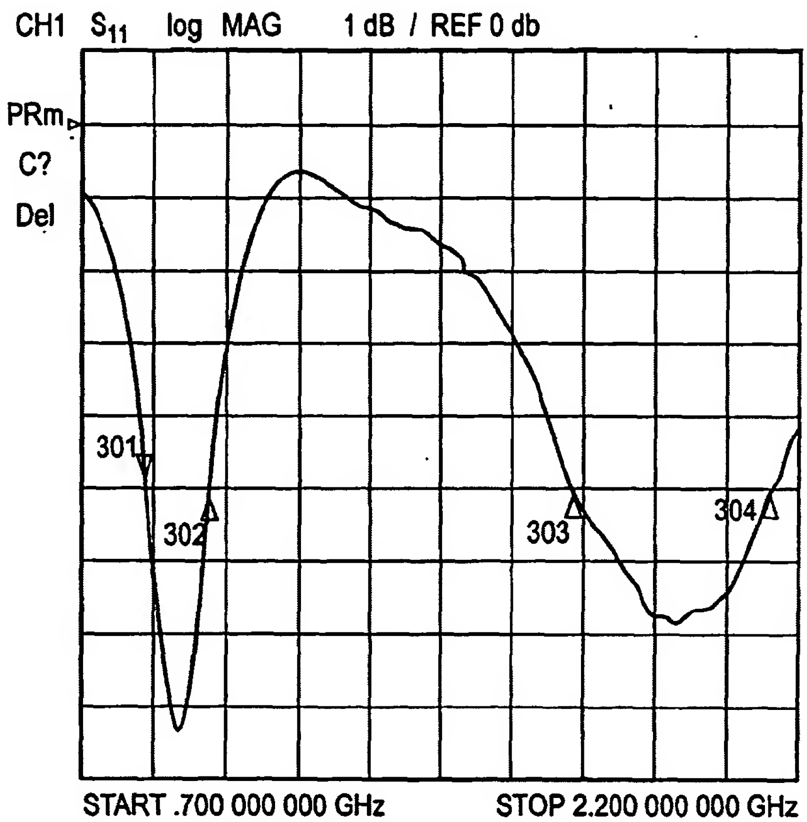

CH1 S11 log MAG 1 dB / REF 0 db
PRm
C?
Del
301
302
303
304
START .700 000 000 GHz
STOP 2.200 000 000 GHz

Fig. 3c

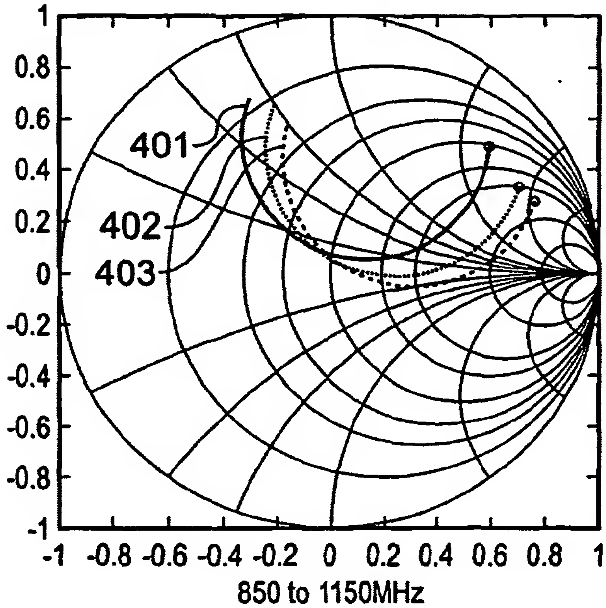

401
402
403
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
850 to 1150MHz

Fig. 4a

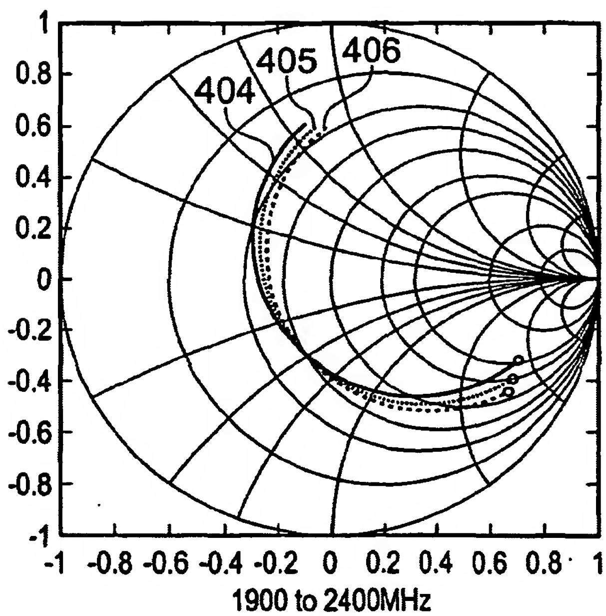

404
405
406
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
1900 to 2400MHz

Fig. 4b

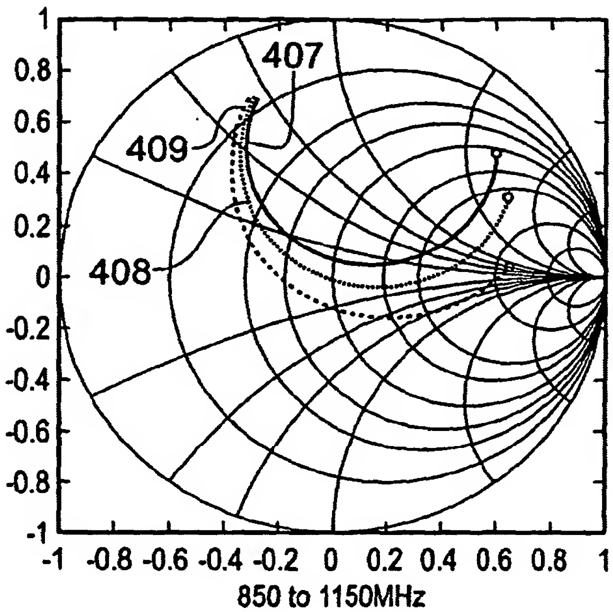
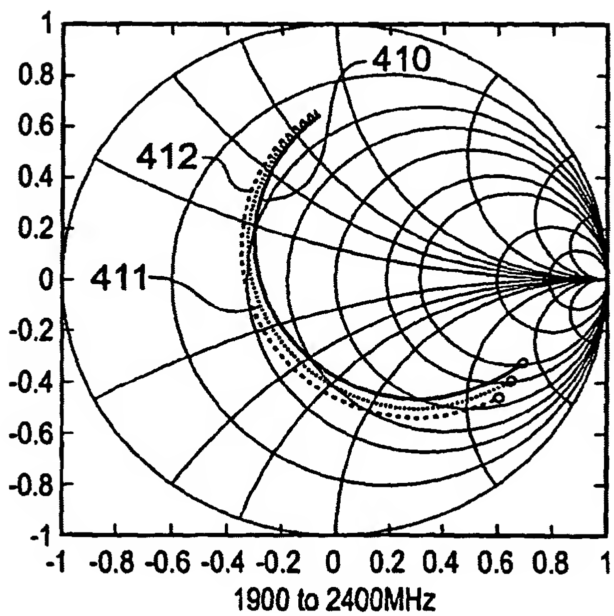

407
409
408
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
850 to 1150MHz

Fig. 4c


410
412
411
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
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-0.8
-1
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
1900 to 2400MHz

Fig. 4d

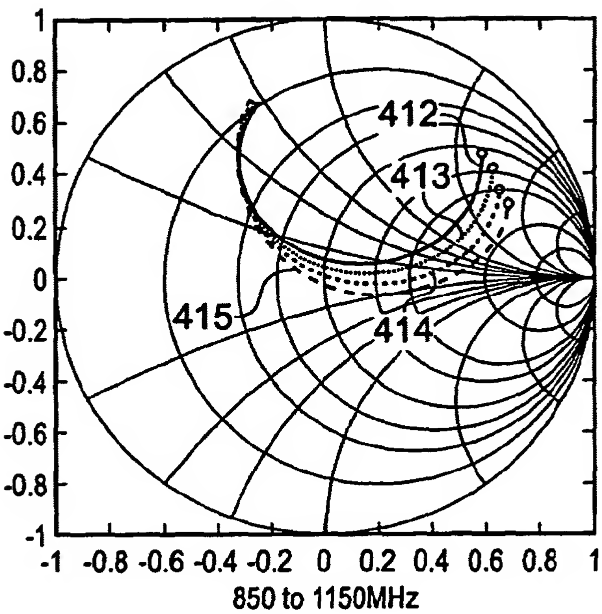
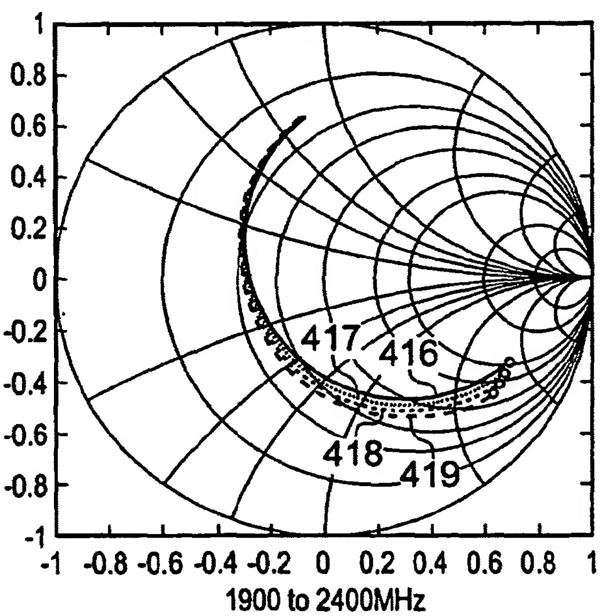

412
413
415
414
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
850 to 1150MHz

Fig. 4e


417
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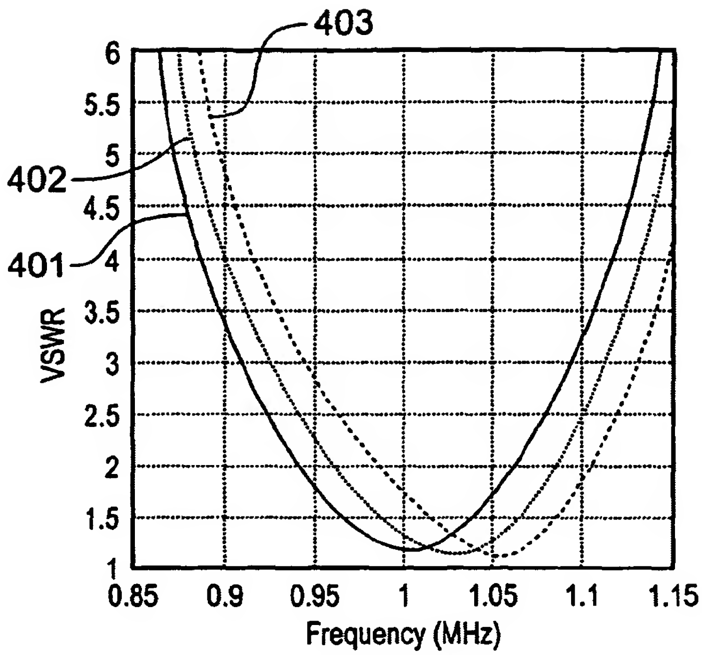
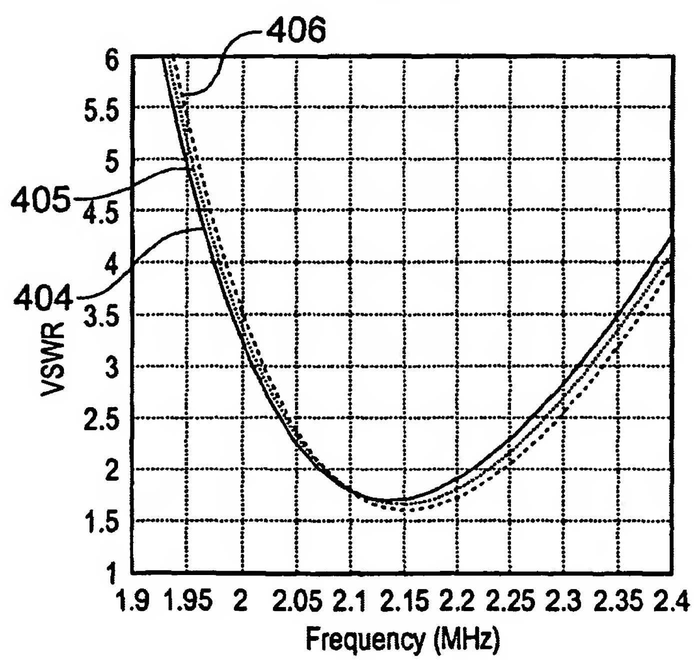
418
419
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
1900 to 2400MHz

Fig. 4f



403
402
401
VSWR
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.85
0.9
0.95
1
1.05
1.1
1.15
Frequency (MHz)

Fig. 5a



406
405
404
VSWR
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
1.9
1.95
2
2.05
2.1
2.15
2.2
2.25
2.3
2.35
2.4
Frequency (MHz)

Fig. 5b

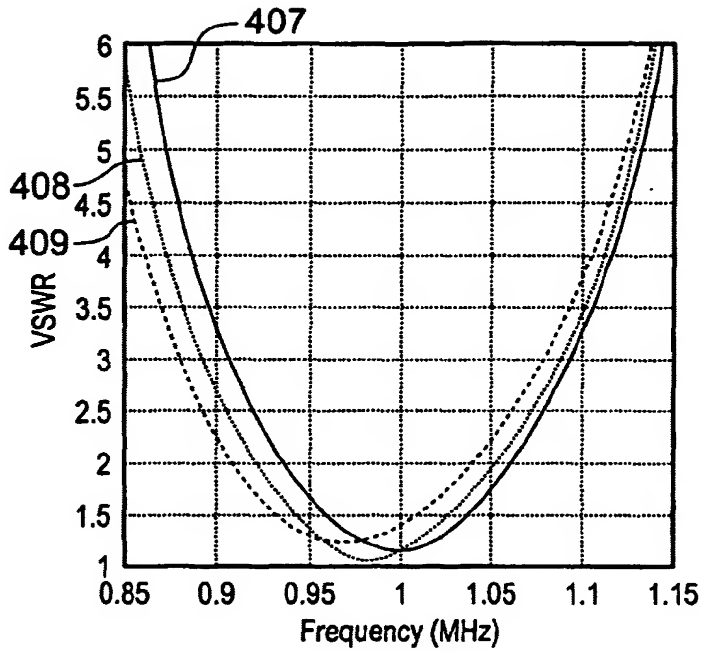
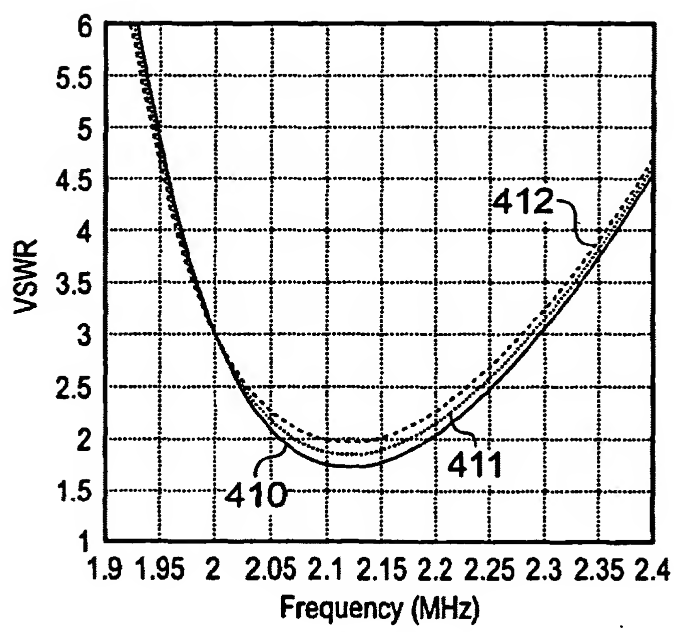

407
408
409
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
VSWR
0.85
0.9
0.95
1
1.05
1.1
1.15
Frequency (MHz)

Fig. 5c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5.5
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2
1.5
1
VSWR
412
411
410
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2.1
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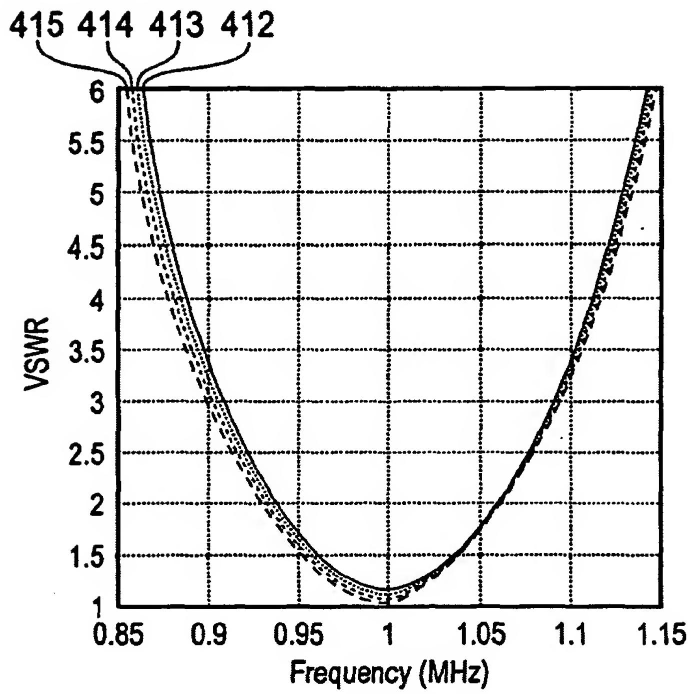
2.4
Frequency (MHz)

Fig. 5d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5.5
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4.5
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2
1.5
1
VSWR
0.85 0.9 0.95 1 1.05 1.1 1.15
Frequency (MHz)

Fig. 5e

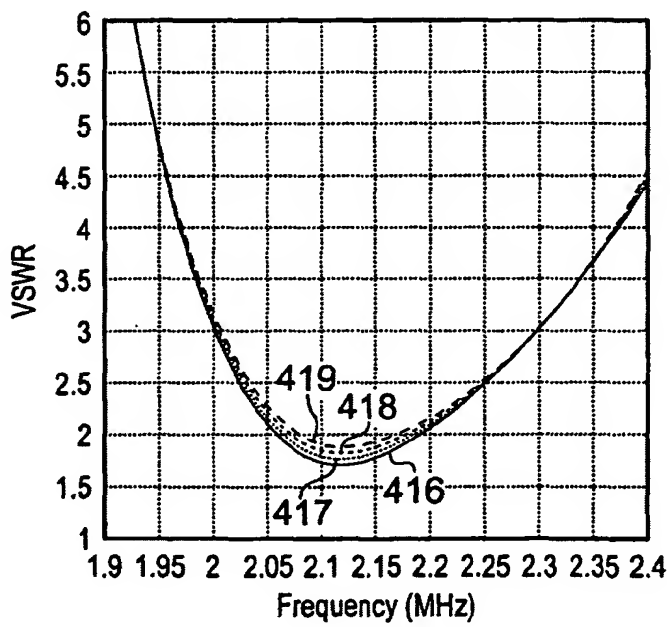
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
VSWR
419
418
416
417
1.9 1.95 2 2.05 2.1 2.15 2.2 2.25 2.3 2.35 2.4
Frequency (MHz)

Fig. 5f

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 6580

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 537 123 A (MANDAI HARUFUMI ET AL) 16 July 1996 (1996-07-16) * claim 1; figures 1-3 * * column 2, line 35 - column 3, line 20 *	1-12	H01Q9/04 H01Q1/24
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Place of search	Date of completion of the search	Examiner
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